From Double Iron to Double Deca Iron Ultra-Triathlon - A Retrospective Data Analysis from 1985 to 2011

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DOI: https://doi.org/10.2478/v10141-012-0013-4

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From Double Iron to Double Deca Iron Ultra-Triathlon – A Retrospective Data Analysis from 1985 to 2011

Authors' contribution:
A) conception and design of the study
B) acquisition of data
C) analysis and interpretation of data
D) manuscript preparation
E) obtaining funding

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ABSTRACT

Participation in ultra-endurance performance is of increasing popularity. We analyzed the historic development of the ultra-triathlon scene from 1985 to 2011 focusing on a) worldwide distribution of competition, b) participation, c) gender, and d) athlete nationality. We examined the participation trends of 3,579 athletes, involving 3,297 men (92.1%) and 300 women (7.9%), using linear regression analyses. Between 1985 and 2011, a total of 96 Double Iron ultra-triathlons (7.6km swimming, 360km cycling, and 84.4km running), 51 Triple Iron ultra-triathlons (11.6km swimming, 540km cycling, and 126.6km running), five Quadruple Iron ultra-triathlons (15.2km swimming, 720km cycling, and 168.8km running), five Quintuple Iron ultra-triathlons (19km swimming, 900km cycling, and 211km running), 11 Deca Iron ultra-triathlons (38km swimming, 1,800km cycling, and 422km running), and two Double Deca Iron ultra-triathlons (76km swimming, 3,600km cycling, and 844km running) were held. In total, 56.7% of the races were in Europe, 37.4% in North America, 5.3% in South America, and less than 1% in Asia. Europeans comprised 80% of the athletes. The number of male participants in Double (r^2 = .56; P < .001) and Triple Iron ultra-triathlon (r^2 = .47; P < .001) and the number of female participants in Double Iron ultra-triathlon (r^2 = .66; P < .001) increased significantly. Less than 8% of the athletes total participated in an ultra-triathlon longer than a Triple Iron ultra-triathlon. Europeans won by far the most competitions in every distance. In conclusion, ultra-triathlon popularity is mainly limited to a) European and North American men and b) Double and Triple Iron ultra-triathlons. Future studies need to investigate the motivation of these ultra-endurance athletes to compete in these extreme races.

KEYWORDS
Triathlon, ultra endurance, nationality, participation, Europe

Introduction

The triathlon is an endurance sport and consists of three single disciplines – swimming, cycling, and running in that order. The triathlon scene started at the beginning of the 20th century. Several sources describe a competition in France in 1920 involving all three triathlon disciplines for the first time (www.thiswastriathlon.org, www.fftri.com, http://sports.espn.go.com). That race was called *les trois sports* and was held in the greater Paris area at Joinville-le-Pont, Melun, and Poissy from 1920 to 1930.

From that time, very little was reported about this swim/bike/run event until it was reinvented in California in 1974, where a group of swimmers, runners, and bikers began training together. On September 25th 1974, the first competition was held at San Diego's Mission Bay including 46 athletes (www.triathlonhistory.com). This date is celebrated as the beginning of the "modern" triathlon. However, the real "wave of success" started with the foundation of the International Triathlon Union (ITU) in Avignon, France, in 1989 (www.triathlon.org). ITU is the sport's international governing body, with the chief goal of putting triathlon on the Olympic program (www.olympic.org). In 2000, the first Olympic triathlon was held in Sydney including 52 male and 48 female participants. Since then, the Olympic distance triathlon has been contested in every summer Olympic Games (www.olympic.org). The distances of the official Olympic triathlon are 1.5km swimming, 40km cycling, and 10km running (Bernard, Sultana, Lepers, Hausswirth, & Brisswalter 2010, Sultana, Brisswalter, Lepers, Hausswirth, & Bernard 2008).

Another phenomenon related to the development of this sport's success during the last decades is the Ironman triathlon. This kind of triathlon consists of a combination of the "Waikiki Rough Water Swim" (3.86km), the "Around Oahu Bike Race" (180.2km), and the "Honolulu Marathon" (42.2km) (www.ironmanworldchampionship.com; Lepers, & Maffiuletti, 2010). In 1978, 12 men initiated this competition (Lepers 2008). Since 1981, the Ironman World Championship is held every year in October in Hawaii and nowadays more than 1,700 triathletes participate each year (Lepers 2008). Due to this great interest, the organizer has had to limit the number of starters: The athletes first have to pass a qualifier race to get a starting place for Ironman Hawaii. To date, worldwide are 27 different qualifier races in 15 different countries (www.ironman.com). Thus, participation in ultra-endurance performance is of increasing popularity. This is also demonstrated in other ultra-endurance races such as the Western States 100-Mile Endurance Run. Both the annual number of races and the number of finishers increased exponentially between 1977 and 2008 (Hoffman, & Wegelin, 2009; Hoffman, Ong, & Wang 2010).

This increasing popularity of ultra-endurance races is surprising because it takes enormous physical and psychical energy to succeed in a race of such long distances. Following the standards of the International Ultra Triathlon Association (IUTA), an ultra-triathlon involves longer distances than a classic Ironman (www.iutasport.com). The prefix "ultra" in sport means an endurance effort of more than six hours (Zaryski, & Smith 2005). Thus, ultra-triathletes rely more on high training volumes than Ironman triathletes (Knechtle, Knechtle, Rüst, & Rosemann 2011a). The ultra-triathlon scene started in 1985 with the doubling of the Ironman distances. The Double Iron ultra-triathlon covers 7.6km swimming, 360km cycling, and 84.4km running. This first ultra-triathlon was held in the United States with 23 athletes (Rüst, Knechtle, Knechtle, Lepers, & Rosemann 2012). Then, in 1988, the first Triple Iron ultra-triathlon covering 11.6km swimming, 540km cycling, and 126.6km running was organized in Le Fontanil, France, with 11 starters. The first Quadruple Iron ultra-triathlon covering 15.2km swimming, 720km cycling, and 168.8km running was in 1989 with two athletes in Den Haag, the Netherlands. Two years later with 10 starters, the first Quintuple Iron ultra-triathlon covering 19km swimming, 900km cycling, and 211km running was held in Den Haag. In 1992, the ultra-triathlon scene moved to Monterrey, Mexico, where 20 athletes started in the first Deca Iron ultra-triathlon, covering 38km swimming, 1,800km cycling, and 422km running (Knechtle, Knechtle, & Lepers, 2011b). To date, the longest version of an ultra-triathlon is a 20 times an Ironman triathlon, called Double Deca Iron ultra-triathlon covering 76km swimming, 3,600km cycling, and 844km running held for the first time with six starters in 1998 (www.multisport.com.mx).

The ultra-triathlon is rarely reported in literature. Most previous studies focused on influences of physiology (Herbst et al. 2011, Knechtle, Knechtle, Rosemann, & Oliver, 2010a; Knechtle, Knechtle, Andonie, & Kohler 2009a, Knechtle, Duff, Amtmann, & Kohler 2008a, Laursen, Knez, Shing, Langill, Rhodes, & Jenkins 2005, Whyte et al. 2000), anthropometry (Knechtle, Knechtle, Rüst, & Rosemann 2011a, Knechtle, Knechtle, Rosemann, & Senn 2011c, Knechtle, Knechtle, & Rosemann 2010b), and training variables (Gulbin, & Gaffney, 1999, Knechtle, Wirth, Baumann, Knechtle, Rosemann, & Senn 2010c, Knechtle, Knechtle, Rüst, & Rosemann 2011a, Knechtle, Knechtle, Rosemann, & Senn 2011c, Lepers, Knechtle, Knechtle, & Rosemann 2011). However, aspects such as nationality trends of ultra-triathletes were

investigated in a very recent study where Rüst, Knechtle, Knechtle, Lepers, and Rosemann (2012) reported European dominance in Double Iron ultra-triathlons worldwide.

The aims of the present study were to describe the historic development of the ultra-triathlon scene worldwide from 1985 to 2011 focusing on a) the worldwide competition distribution, b) participation trends, and c) athletes' nationality. We hypothesized that a) most of ultra-triathlons were held in Europe, b) there was an increase in ultra-triathlon participation, and c) that ultra-triathletes originated mainly from Europe.

Materials and methods

All participants who ever started in an ultra-triathlon longer than an Ironman between 1985 and 2011 were analyzed regarding participation aspects and success related to origin and gender. The data set from this study was obtained from the race directors and the IUTA (www.iutasport.com).

In total, data was available for 3,579 athletes, including 300 women and 3,297 men. The athletes originated from all continents. For the analyses of the number of participants per year and per continent, all participants were included independent from their success (i.e. having finished the race or not). To investigate the percentage of finishers, the finisher rate was calculated as follows: 100 / (total number of participants) x (number of finishers). For the calculation of the cumulative number of victories per continent, in every year the total number of wins (i.e. shortest total race time) was counted for every continent, separated by distance of race.

Linear regression analyses were used to examine changes in data across time. Statistical analyses were performed using IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA) and GraphPad Prism Version 5, GraphPad Software, La Jolla, CA, USA).

Results

Competition locations

To date, six different race distances of ultra-triathlon are known (Table 1). Europe has a competition for every distance except Double Deca Iron ultra-triathlon; Europe is the only continent with Quadruple Iron ultra-triathlons. North America has had Double Iron ultra-triathlons, Triple Iron ultra-triathlons, and Deca Iron ultra-triathlons. The only two Double Deca Iron ultra-triathlons ever organized were in Monterrey, Mexico. In Mexico were also three of the world's five Quintuple Iron ultra-triathlons and nine of the world's 11 Deca Iron ultra-triathlons. Ecuador, with nine Double Iron ultra-triathlons, is the only South American country where ultra-triathlons were organized (Table 2). To date, one Double Iron ultra-triathlon was held in Asia in the United Arab Emirates and no race has been held yet in Africa or Australia.

Table 1. Ultra-triathlon distances with the corresponding swimming, cycling, and running distances

Distance	Swimming	Cycling	Running
Ironman	3.8 km	180 km	42.2 km
Double Iron ultra-triathlon	7.6 km	360 km	84.4 km
Triple Iron ultra-triathlon	11.4 km	540 km	126.6 km
Quadruple Iron ultra-triathlon	15.2 km	720 km	168.8 km
Quintuple Iron ultra-triathlon	19 km	900 km	211 km
Deca Iron ultra-triathlon	38 km	1,800 km	422 km
Double Deca Iron ultra-triathlon	76 km	3,600 km	844 km

Of all ultra-triathlons, 56.7% were held in Europe, 37.4% in North America, 5.3% in South America, and less than 1% in Asia. Concentrating on the European countries, most of the ultra-triathlons were held in Germany (22 races), France (19 races), and Austria (15 races). During the last five years, new race sites for ultra-triathlons such as Slovenia, Switzerland, and the United Arab Emirates entered the IUTA circuit. In the

last 15 years, Double and Triple Iron ultra-triathlons were the only ultra-triathlon distances in Europe, except one Deca Iron ultra-triathlon held in France in 2006.

Table 2. All competitions tabulated concerning the distances, the years, and the countries where they were held

		Distance (Ironmans)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AS	UAE	2x																							■				
EU	AUT	2x																		■	■	■	■	■	■		■		■
		3x												■	■	■	■	■						■	■				
	BEL	2x								■	■																		
	ESP	2x												■															■
	FRA	2x						■	■	■	■								■										■
		3x				■	■	■	■	■		■	■	■	■	■		■	■										
		10x																						■					
	GBR	2x																								■	■	■	■
		3x																										■	■
	GER	2x																		■		■							
		3x								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	HUN	2x																								■	■	■	
		4x							■	■	■	■																	
	LTU	2x											■	■	■	■	■	■		■	■	■	■						
	NED	2x					■	■	■	■	■		■				■												
		4x					■																						
		5x							■			■																	
	SLO	2x																									■	■	■
	SUI	2x																											■
NA	CAN	2x																■	■	■	■	■	■	■	■	■			
	USA	2x	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■
		3x																■	■	■		■	■	■	■	■	■	■	■
		10x																				■							
	MEX	2x															■		■										■
		5x																					■			■		■	
		10x								■		■	■		■	■		■		■						■		■	
		20x														■												■	
SA	ECU	2x														■	■	■	■	■	■	■	■	■					

2x: Double Iron ultra-triathlon, 3x: Triple Iron ultra-triathlon, 4x: Quadruple Iron ultra-triathlon, 5x: Quintuple Iron ultra-triathlon, 10x: Deca Iron ultra-triathlon, 20x Double Deca Iron ultra-triathlon

Participation

Table 3 presents the number of races held for each distance. The participation distribution in the different race distances was as follows: 57.4% of all athletes participated in a Double Iron ultra-triathlon, 34.7% in a Triple Iron ultra-triathlon, 4.4% in a Deca Iron ultra-triathlon, 1.8% in a Quintuple Iron ultra-triathlon, 1.6% in a Quadruple Iron ultra-triathlon, and 0.4% in a Double Deca Iron ultra-triathlon. The detailed numbers of male and female starters per year are shown in Figure 1 for Double Iron ultra-triathlon and Triple Iron ultra-triathlon (Panel A), Quadruple Iron ultra-triathlon and Quintuple Iron ultra-triathlon (Panel B) as well as for Deca Iron ultra-triathlon and Double Deca Iron ultra-triathlon (Panel C). In Double Iron ultra-triathlon, female (r^2 = .66; P < .001) as well as male participation (r^2 = .56; P < .001) increased significantly. In Triple Iron ultra-triathlon, participation also increased (r^2 = .47; P < .001) (Figure 2). For the other distances, a small number of 391 athletes of total 3,579 participants showed no increase in participation.

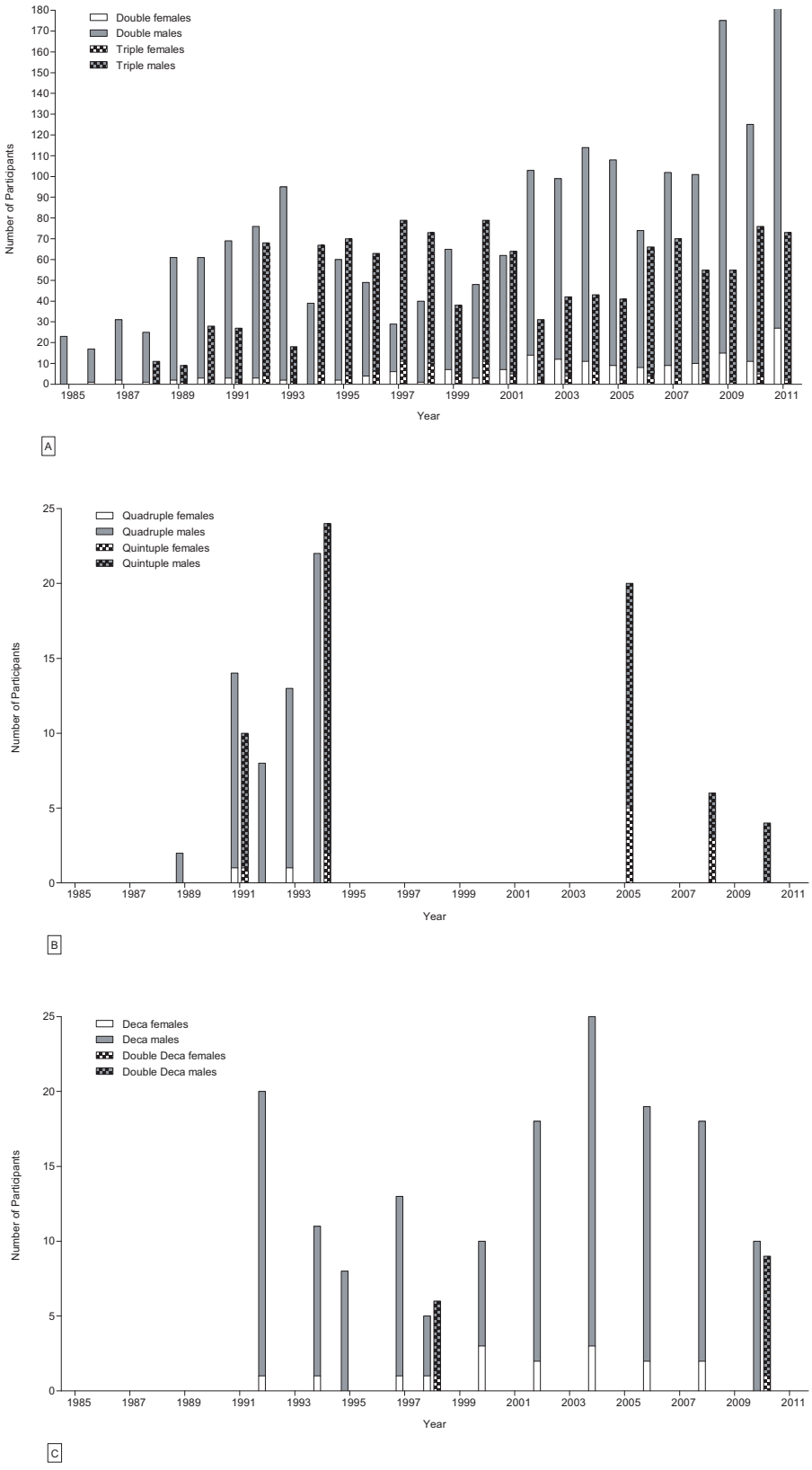


Figure 1. Number of male and female participants (*i.e* finishers + non finishers) per year in Double Iron ultra-triathlon and Triple Iron ultra-triathlon (Panel A), Quadruple Iron ultra-triathlon and Quintuple Iron ultra-triathlon (Panel B) as well as in Deca Iron ultra-triathlon and Double Deca Iron ultra-triathlon (Panel C)

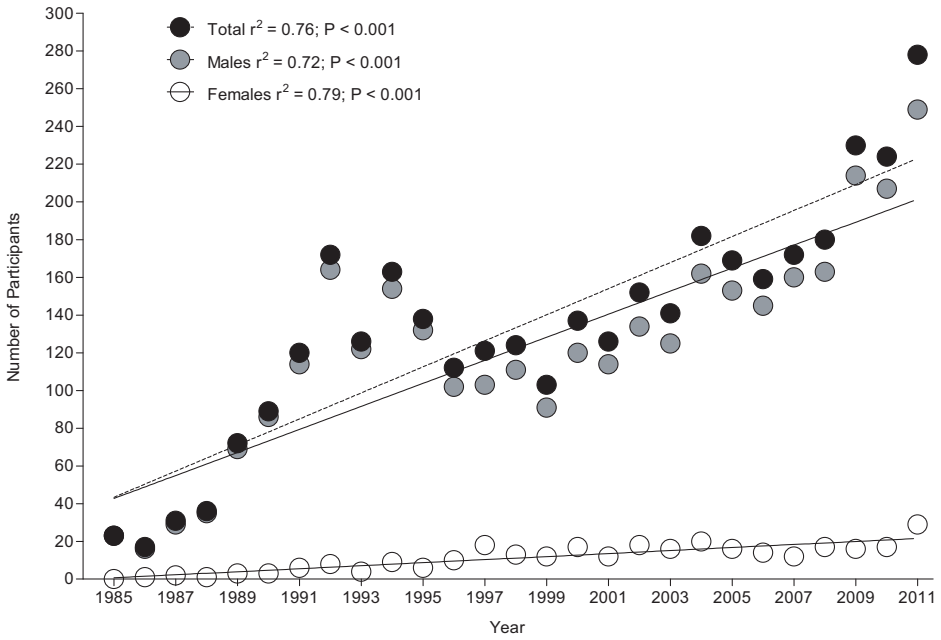


Figure 2. Number of male and female participants of every ultra-triathlon distance as well as total number of participants per year. The number of male, female as well as total number of participants per year increased significantly over time

Table 3. Ultra-triathlon history

Distances	Year of the first event	Number of events held until 2011	Total number of male participants until 2011	Total number of female participants until 2011
Double Iron ultra-triathlon	1985	96	1,883	173
Triple Iron ultra-triathlon	1988	51	1,150	96
Quadruple Iron ultra-triathlon	1989	5	57	2
Quintuple Iron ultra-triathlon	1991	5	53	11
Deca Iron ultra-triathlon	1992	11	141	16
Double Deca Iron ultra-triathlon	1998	2	13	2

Gender and nationality

From 1985 to 2010, a total of 3,579 athletes participated in an ultra-triathlon involving 92.1% men and 7.9% women. Male ultra-triathletes originated from all over the world (Figure 3). Regarding female participation, no female athlete came from Australia or South America. There were more male than female participants of every nation except for African nations, from which women (over 10 athletes) were more numerous than men (under 10 athletes). Europeans accounted for 76.7% of ultra-triathletes, while 20% were North Americans and 0.9% South Americans, 0.6% Africans, 1.3% Asians, and 0.6% Australians. Europeans outnumbered the other nations on every continent except for North America, where most participants were North Americans (Figure 3). A similar finding could be observed in South America, where men from the continent outnumbered North Americans and amounted to the second-most numerous groups after the Europeans.

Race outcome

The finisher rate of Double Iron ultra-triathlons, Triple Iron ultra-triathlons, Quadruple Iron ultra-triathlons, and Quintuple Iron ultra-triathlons amounted on average to 80% for both women and men (Figure 4). However, the percentage of female finishers in Deca Iron ultra-triathlons and Double Deca Iron ultra-triathlons amounted to just 50% as opposed to the male competitors who finished these competitions with a mean rate of 80%. European athletes won 79 to 100% of all races, depending on the discipline (Figure 5).

North American athletes could record 17 of total 96 victories in Double Iron ultra-triathlons and six of 51 total Triple Iron ultra-triathlons; South American athletes won three Double Iron ultra-triathlons. To date, no athlete from Asia, Australia, or Africa has won an ultra-triathlon (Figure 5).

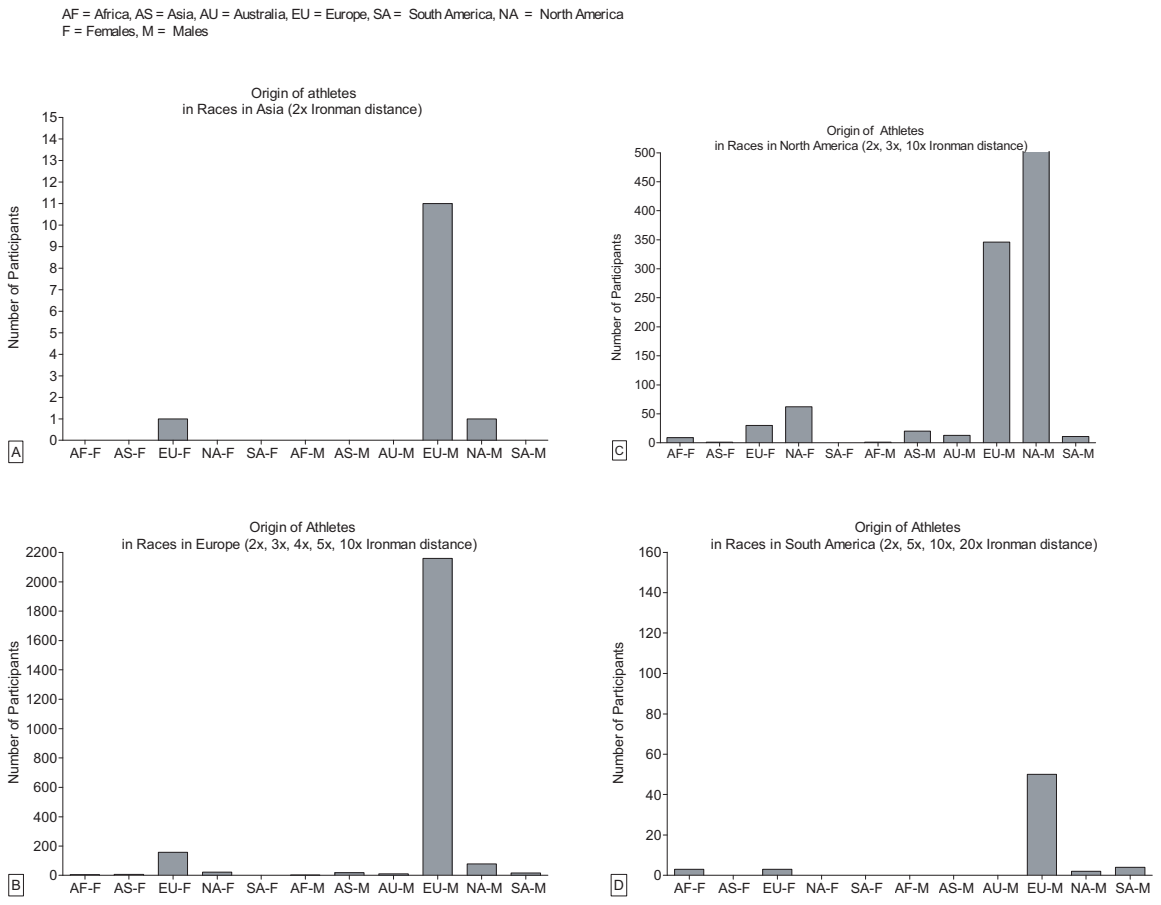


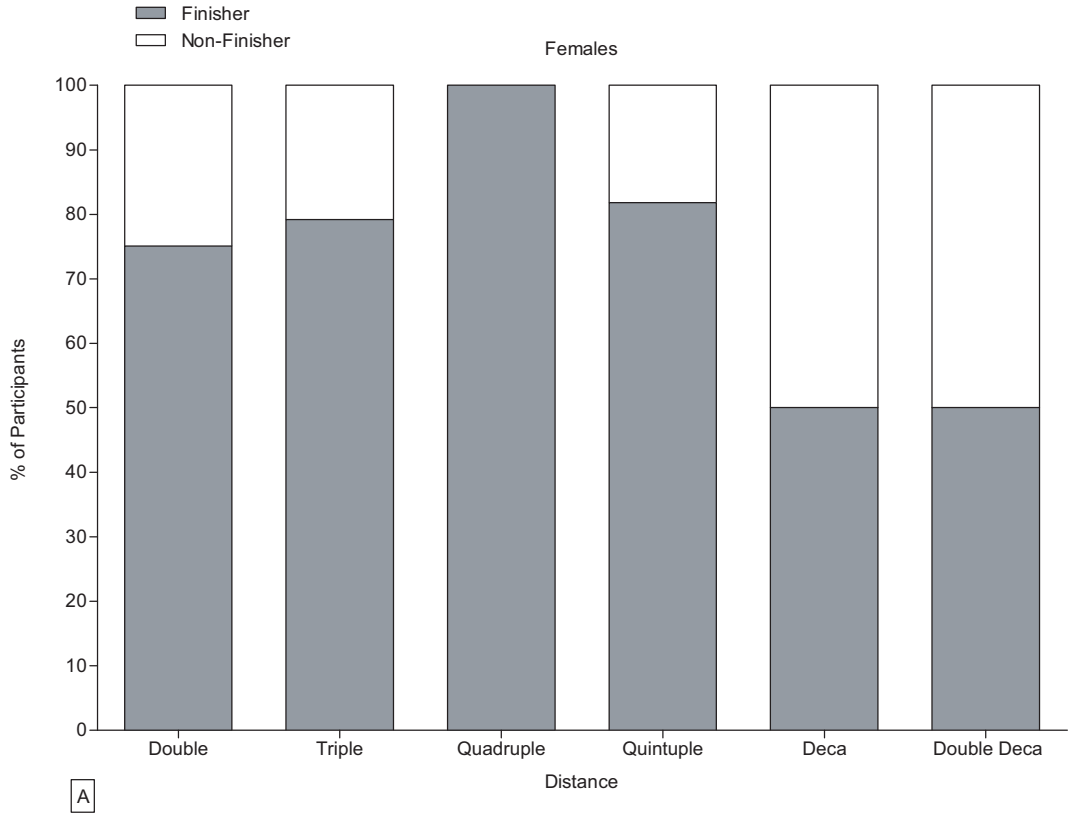
Figure 3. Number of participants of every ultra-triathlon distance by continental origin in races in Asia (Panel A), Europe (Panel B), North America (Panel C), and South America (Panel D)

Discussion

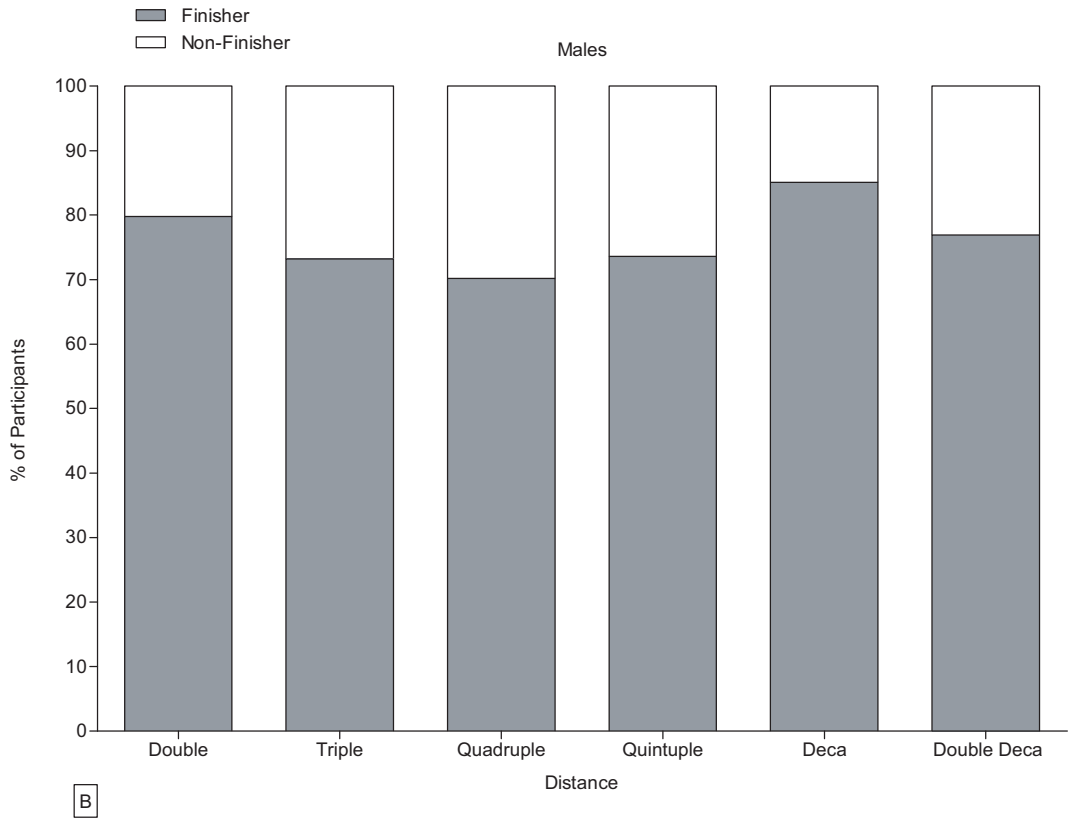
The aims of this study were to describe the historic development of ultra-triathlon from 1985 to 2011 focusing on worldwide distribution trends of competitions, participation, gender and the nationality of the athletes, and race results. Europeans dominated ultra-triathlons in most aspects such as participation, performance, and the organization of Double Iron ultra-triathlons, Triple Iron ultra-triathlons, and Quadruple Iron ultra-triathlons.

A first important finding was that most of the competitions (55%) were held in Europe. However, most very long distances such as Quintuple Iron ultra-triathlons, Deca Iron ultra-triathlons, and all Double Deca Iron ultra-triathlons were organized in Monterrey, Mexico. Only 37% of the ultra-triathlons were held in North America, where the ultra-triathlon scene began. Thus, there must be other reasons why the longer ultra-triathlon distances were held mostly in Mexico. On the one hand, the climate in Monterrey is moderate and dry during the whole year (www.world-climates.com). This is important for an outdoor sport which takes several days. Costs are generally lower in Mexico than in Europe or other North American locations, making it easier to organize such a large event on a smaller budget as a lot of money is required to maintain the high standards of infrastructure, security, organization, and marketing for an ultra-triathlon (www.iutasport.com). The organizers in Mexico have enjoyed a great experience and have been supported by sponsors and volunteers over the years (www.multisport.com.mx; www.iutasport.com). Thus, Monterrey in Northern Mexico, with its proximity to the US and Canada, is a perfect place to organize long-distance

ultra-triathlons. Therefore, it is difficult for organizers in new countries to start up with an ultra-triathlon longer than a Triple Iron ultra-triathlon. However regarding the shorter distances, Double Iron ultra-triathlons were held in five new countries and Triple Iron ultra-triathlons were held in only one new country during the last five years.



A



B

Figure 4. Percentage of finisher and non-finisher per distance in females (Panel A) and males (Panel B)

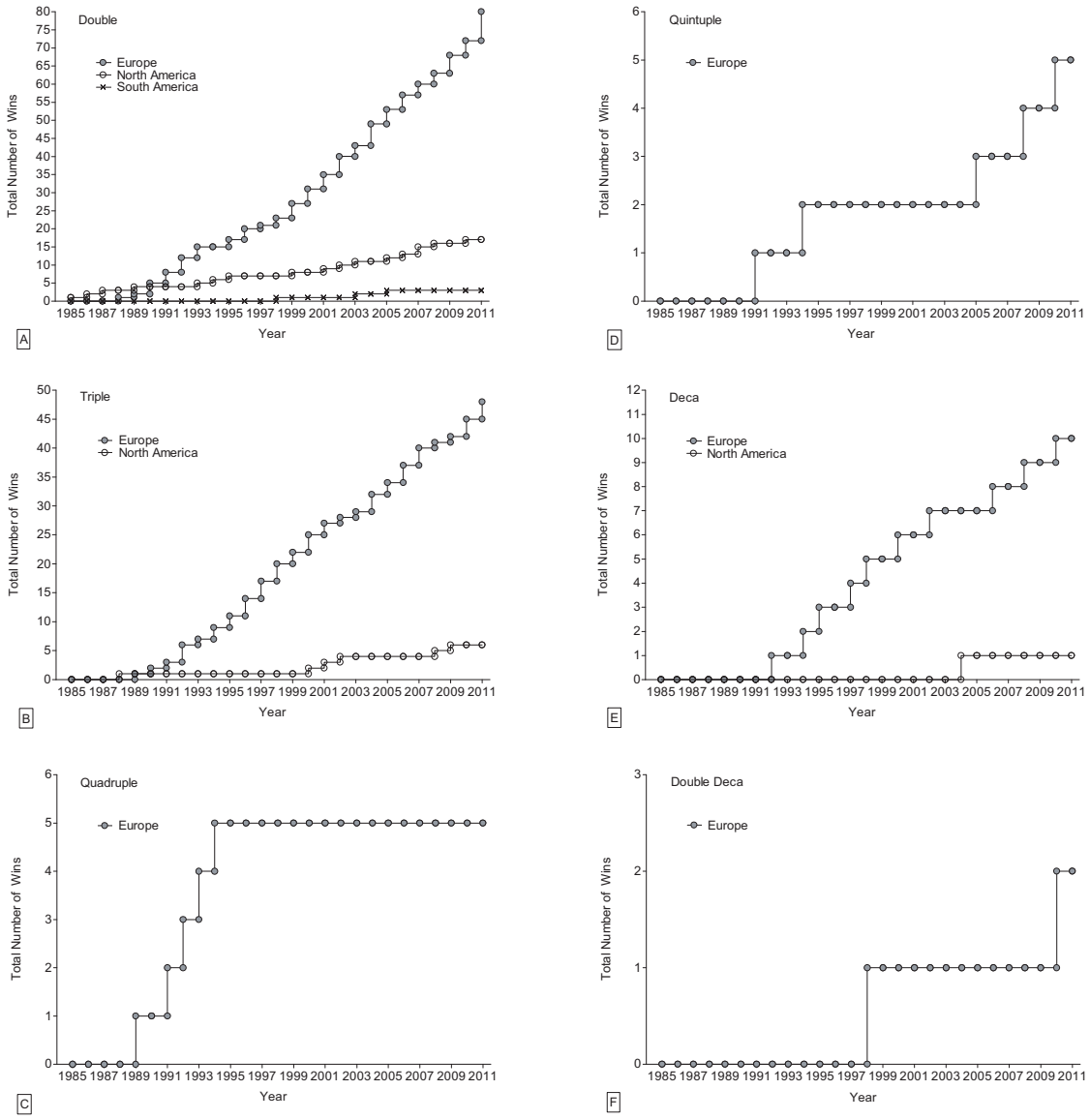


Figure 5. Cumulative number of victories per continent and distance for Double Iron ultra-triathlon in (Panel A), Triple Iron ultra-triathlon (Panel B), Quadruple Iron ultra-triathlon (Panel C), Quintuple Iron ultra-triathlon (Panel D), Deca Iron ultra-triathlon (Panel E), and Double Deca Iron ultra-triathlon (Panel F). No athlete from Asia, Australia or Africa could ever win an ultra-triathlon. European athletes clearly dominate all distances. North American athletes could record some wins in Double Iron ultra-triathlon and Triple Iron ultra-triathlon and South American athletes in Double Iron and Deca Iron ultra-triathlon

A further important finding was a significant increase of overall participation in Double Iron ultra-triathlons and of male participation in Triple Iron ultra-triathlons. The missing increase of participation in Quadruple Iron ultra-triathlons, Quintuple Iron ultra-triathlons, Deca Iron ultra-triathlons, and Double Deca Iron ultra-triathlons might be explained by several reasons. The small number of participants (7.9% of all ultra-triathletes) in these very long distances shows that the popularity of distances longer than a Triple Iron ultra-triathlon is not yet great. In addition, the distances differ enormously between the single competitions. Much more endurance, training, and mental strength is required for a successful finish in a Double Deca Iron ultra-triathlon than for the ten-times shorter Double Iron ultra-triathlon (Knechtle, Duff, Amtmann & Kohler 2008a, Knechtle, Schwanke, Knechtle, & Kohler 2008c, Knechtle, Knechtle, Rüst & Rosemann 2011a, Lepers, Knechtle, Knechtle & Rosemann 2011, Zaryski & Smith 2005). Thus, a Triple Iron ultra-triathlete

has to train for more hours than an Ironman-triathlete to reach the same level of performance (Knechtle, Knechtle, Rüst, & Rosemann 2011a). However, the average Triple Iron ultra-triathlete trains already for 19.3 hours a week (Knechtle, Knechtle, Rüst & Rosemann 2011a). Therefore, only a few ultra-triathletes of a very high level are able to complete an ultra-triathlon longer than a Triple Iron ultra-triathlon distance. The athletes often start with shorter distances (Lepers, Knechtle, Knechtle & Rosemann 2011). Therefore, the names of athletes who started a longer ultra-triathlon distance already appeared on the ranking lists of previous Double Iron ultra-triathlons and Triple Iron ultra-triathlons (www.iutasport.com). A small number of participants leads to fewer competitions because of the tremendous effort to organize an ultra-triathlon has less pay off the fewer athletes start. Regarding ultra-triathlons distances longer than the Triple Iron ultra-triathlon, the Deca Iron ultra-triathlons in Monterrey (Mexico) is the only competition of this distance held regularly during the last two decades.

Another finding was that participation was dominated by Europeans with 80% of total athletes, followed by North Americans with 20% of total athletes. The other continents accounted for just ~2% of the starters. The rate of male starters (92.1%) was by far higher than the female rate (7.9%). The number of participants depended on, among others, how many competitions were held in a certain country. Thus, North Americans could outnumber Europeans in competitions in North America. As no competition has been held yet in Africa and Australia, it has not been as popular there as in Europe where the most races were held. That might explain the very small number of African and Australian ultra-triathletes.

Ultra-triathletes have to bear enormous challenges. They have to be in a very good physical and psychical condition to complete such a race because an ultra-triathlon challenges the human body enormously and the recovery phase can require several days (Knechtle, Duff, Amtmann & Kohler 2008a, Knechtle, Schwanke, Knechtle & Kohler 2008c, Knechtle, Knechtle, Andonie & Kohler 2009a, Knechtle, Vinzent, Kirby, Knechtle & Rosemann 2009b, Knechtle, Knechtle, Rosemann & Oliver 2010a, 2011a). The athletes also have to bear the costs of their own support crew to provide nutrition and changes of clothing and equipment, travel costs and accommodation, and ~$200 to $700 to start in a competition (www.iutasport.com). All in all, the costs amount to several thousand dollars per year for an active ultra-triathlete. In contrast to all that, a podium rank prize amounts to ~$200 to $5,000 (www.iutasport.com). Therefore, it is impossible for an athlete to earn money by competing in ultra-triathlons. It is not incorrect to call ultra-triathlon a “luxurious sport” and it seems more understandable that this sport could not extend all over the world and in particular the economically underdeveloped world. In their study, Hoffman and Fogard (2012) describe a typical ultra-endurance runner as a well-educated, middle-aged, married man who rarely misses work due to illness or injury. That finding confirms the characteristics of our findings of a typical ultra-triathlete being a man from an industrialized country, such as in Europe or North America.

Our last important finding was that the largest number of winners originated from Europe in each of the six ultra-triathlon distances. Europeans won all Quadruple Iron ultra-triathlons, Quintuple Iron ultra-triathlons, and Double Deca Iron ultra-triathlons. Some indications show that athletes from specific nations or areas dominate in certain sports. For example, East Africans are known as the best distance runners (Onywera, Scott, Boit & Pitsiladis 2006, Larsen 2003). The reason for this is not completely known yet, but several studies are analyzing this aspect (Ash et al. 2011, Onywera, Scott, Boit & Pitsiladis 2006, Yang et al. 2007). Kenyan runners have special physiological characteristics which could include favorable genetic endowment and advantageous environmental conditions (Onywera, Scott, Boit & Pitsiladis 2006) and East Africans in general seem to have a better running economy than Caucasian runners (Lucia et al. 2006; Weston, Mbambo, & Myburgh 2000). However, no African athlete could ever win an ultra-triathlon. Therefore, performance might not be the only reason for the high rate of European champions in ultra-triathlons. Regarding the origin of the athletes, it becomes obvious that national distribution is very irregular as almost no athletes came from East Africa. Thus, the chances of winning a competition were not the same for every nation. In the initial years, ultra-triathlons were held almost exclusively in Europe. Due to this and the low prize money, there was no stimulus for non-Europeans to train such a long time for a race which is not even known in their country. Years of training and enough prerace experience are necessary to finish

such a competition successfully (Knechtle, Knechtle, & Lepers 2011b, Gulbin, & Gaffney 1999). The high average finisher rate of 80% shows that the ultra-triathlon athletes must be experienced in competing endurance races.

Limitations

Interpretation of such cross-sectional comparisons in ultra-triathlon development must be made carefully. It is possible that other factors would have contributed to these observations. Factors as such anthropometry (Knechtle, Knechtle, Rüst, & Rosemann 2011a, Knechtle, Knechtle, Rosemann, & Senn 2011c, Knechtle, Knechtle & Rosemann 2010b), training (Gulbin, & Gaffney 1999, Knechtle, Knechtle, Rüst & Rosemann 2011a, Knechtle, Knechtle, Rosemann & Senn 2011c), prerace preparation (www.iutasport.com; Binnie, Landers, & Peeling 2011), nutrition (Knechtle, & Boutellier 1994), athlete experience (Knechtle, Knechtle, Schulze & Kohler 2008b, Knechtle, Knechtle, Rosemann, & Senn 2011c), and weather influences (Knechtle, Christinger, Kohler, Knechtle, & Rosemann 2009c, Pereira et al. 2011) have been ignored because they influence the performance and not the number of participants.

Conclusions

To summarize, most of the ultra-triathlons (55.5%) were held in Europe but Mexico was the leading organizer of ultra-triathlon distances longer than a Triple Iron ultra-triathlon. In Double Iron ultra-triathlon and Triple Iron ultra-triathlon, a significant increase of participants was found. Most of the ultra-triathletes were men (92.1%) and originated from Europe (80%). European ultra-triathletes also won the most competitions by far (79-100%) followed by North American ultra-triathletes. Future studies should continue to analyze the ultra-triathlon scene to find out more about the development in popularity and athlete performance and characteristics. In addition, the influence of physiology, training, nutrition, and environment should be examined to find new results about the capacity of human body and the athletes' motivation to compete in such extreme races.

REFERENCES

Ash, G.I., Scott, R.A., Deason, M., Dawson, T.A., Wolde, B., Bekele, Z., Teka, S., & Pitsiladis, Y.P. (2011). No association between ACE gene variation and endurance athlete status in Ethiopians. *Medicine and Science in Sports and Exercise*, 43*,* 590-597.

Bernard, T., Sultana, F., Lepers, R., Hausswirth, C., & Brisswalter, J. (2010). Age-related decline in Olympic triathlon performance: effect of locomotion mode. *Experimental Aging Research*, 36, 64-78.

Binnie, M.J., Landers, G., & Peeling, P. (2011). Effect of different warm-up procedures on subsequent swim and overall sprint distance triathlon performance. *Journal of Strength and Conditioning Research*, E-pub.

Gulbin, J.P., & Gaffney, P.T. (1999). Ultraendurance triathlon participation: typical race preparation of lower level triathletes. *Journal of Sports Medicine and Physical Fitness*, 39, 12-15.

Herbst, L., Knechtle, B., Lopez, C.L., Andonie, J.L., Fraire, O.S., Kohler, G., Rüst, C.A., & Rosemann, T. (2011). Pacing strategy and change in body composition during a Deca Iron triathlon, *Chinese Journal of Physiology*, 54, 255-263.

Hoffman, M.D., & Fogard, K. (2012). Demographic characteristics of 161-km ultramarathon runners. *Research in Sports Medicine,* 20, 59-69.

Hoffman, M.D., Ong, J.C., & Wang, G. (2010). Historical analysis of participation in161km ultramarathons in North America. *The International Journal of the History of Sport,* 27, 1877-1891.

Hoffman, M. D., & Wegelin, J. A., (2009). The Western States 100-Mile Endurance Run: participation and performance trends. *Medicine and Science in Sports and Exercise,* 41, 2191-2198.

Knechtle, B., & Boutellier, U. (1994). Nutrition in long physical endurance events. *Praxis (Bern 1994),* 89, 2051-62.

Knechtle, B., Christinger, N., Kohler, G., Knechtle, P., & Rosemann, T. (2009c). Swimming in ice cold water. *Irish Journal of Medical Science,* 178, 507-511.

Knechtle, B., Duff, B., Amtmann, G., & Kohler, G. (2008a). An ultratriathlon leads to a decrease of body fat and skeletal muscle mass--the Triple Iron Triathlon Austria 2006. *Research in Sports Medicine,* 16, 97-110.

Knechtle, B., Knechtle, P., Andonie, J.L., & Kohler, G. (2009a). Body composition, energy, and fluid turnover in a five-day multistage ultratriathlon: a case study. *Research in Sports Medicine,* 17, 104-120.

Knechtle, B., Knechtle, P., & Lepers, R. (2011b). Participation and performance trends in ultra-triathlons from 1985 to 2009. *Scandinavian Journal of Medicine and Science in Sports,* 21, e82-e90.

Knechtle, B., Knechtle, P., & Rosemann, T. (2010b). Similarity of anthropometric measures for male ultra-triathletes and ultra-runners. *Perceptual and Motor Skills,* 111, 805-818.

Knechtle, B., Knechtle, P., Rosemann, T., & Oliver, S. (2010a). A Triple Iron triathlon leads to a decrease in total body mass but not to dehydration. *Research Quarterly for Exercise & Sport*, 81, 319-327.

Knechtle, B., Knechtle, P., Rüst, C.A., & Rosemann, T. (2011a). A comparison of anthropometric and training characteristics of Ironman triathletes and Triple Iron ultra-triathletes. *Journal of Sports Sciences,* 29, 1373-1380.

Knechtle, B., Knechtle, P., Rosemann, T., & Senn, O. (2011c). Personal best time, not anthropometry or training volume, is associated with total race time in a triple iron triathlon, *Journal of Strength and Conditioning Research,* 25, 1142-50.

Knechtle, B., Knechtle, P., Schulze, I., & Kohler, G. (2008b). Vitamins, minerals and race performance in ultra-endurance runners - Deutschlandlauf 2006. *Asia Pacific Journal of Clinical Nutrition,* 17, 194-198.

Knechtle, B., Schwanke, M., Knechtle, P., & Kohler, G. (2008c). Decrease in body fat during an ultra-endurance triathlon is associated with race intensity. *British Journal of Sports Medicine,* 42, 609-613.

Knechtle, B., Vinzent, T., Kirby, S., Knechtle, P., & Rosemann, T. (2009b). The recovery phase following a Triple Iron triathlon. *Journal of Human Kinetics,* 21, 65-74.

Knechtle, B., Wirth, A., Baumann, B., Knechtle, P., Rosemann, T., & Senn, O. (2010c). Differential correlations between anthropometry, training volume and performance in male and female Iron triathletes. *Journal of Strength and Conditioning Research,* 24, 2785-2793.

Larsen, H.B. (2003). Kenyan dominance in distance running. *Comparative Biochemistry and Physiology. Part A, Molecular and integrative Physiology,* 136, 161-170.

Laursen, P.B., Knez, W.L., Shing, C.M., Langill, R.H., Rhodes, E.C., & Jenkins, D.G. (2005). Relationship between laboratory-measured variables and heart rate during an ultra-endurance triathlon. *Journal of Sports Sciences,* 23, 1111-1120.

Lepers, R. (2008). Analysis of Hawaii Ironman performances in elite triathletes from 1981 to 2007. *Medicine and Science in Sports and Exercise,* 40, 1828-1834.

Lepers, R., Knechtle, P., Knechtle, B., & Rosemann, T. (2011) *Analysis of ultra-triathlon performances. Open Access Journal of Sports Medicine,* 2, 131-136.

Lepers, R., & Maffiuletti, N.A. (2010). Age and gender interactions in ultraendurance performance: insight from the triathlon. *Medicine and Science in Sports and Exercise,* 43, 134-139.

Lucia, A., Esteve-Lanao, J., Oliván, J., Gómez-Gallego, F., San Juan, A.F., Santiago, C., Pérez, M., Chamorro-Viña, C., & Foster, C. (2006). Physiological characteristics of the best Eritrean runners-exceptional running economy. *Applied Physiology, Nutrition, and Metabolism*, 31, 530-540.

Onywera, V. O., Scott, R. A., Boit, M.K., & Pitsiladis, Y. P. (2006). Demographic characteristics of elite Kenyan endurance runners. *Journal of Sports Sciences,* 24, 415-422.

Pereira, W.M., Ferreira, L.A.,Rossi, L.P., Kerpers, I.I., Grecco, St.S.A., de Paula, A.R.Jr, & Oliveira, C.S. (2011). Influence of heat on fatigue and electromyographic activity of the biceps brachii muscle. *Journal of Bodywork and Movement Therapy,* 15, 478-484.

Rüst, C., Knechtle, B., Knechtle, P., Lepers, R., & Rosemann, T. (2012). European athletes dominate performances in Double Iron ultra-triathlons – a retrospective data analysis from 1985 to 2010. *European Journal of Sport Science*, DOI: 10.1080/17461391.2011.641033.

Sultana, F., Brisswalter, J., Lepers, R., Hausswirth, C., & Bernard, T. (2008). Effects of age and gender on Olympic triathlon performances. *Science and Sports,* 23, 130-135.

Weston, A.R., Mbambo, Z., & Myburgh, K.H. (2000). Running economy of African and Caucasian distance runners. *Medicine and Science in Sports and Exercise*, 32, 1130-1134.

Whyte, G., Lumley, S., George, K., Gates, P., Sharma, S., Prasad, K., & McKenna, W.J. (2000). Physiological profile and predictors of cycling performance in ultra-endurance Triathletes. *The Journal of Sports Medicine and Physical Fitness,* 40, 103-109.

Yang, N., MacArthur, D.G., Wolde, B., Onywera, V.O., Boit, M.K., Lau, S.Y., Wilson, R.H., Scott, R.A., Pitsiladis, Y. P., & North, K. (2007). The ACTN3 R577X polymorphism in East and West African athletes. *Medicine and Science in Sports and Exercise*, 39, 1985-1988.

Zaryski, C., & Smith, D.J. (2005). Training principles and issues for ultra-endurance athletes. *Current Sports Medicine Reports,* 4, 165-170.

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